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PUNISHMENT OF APPETITIVELY REINFORCED INSTRUMENTAL BEHAVIOR: FACTORS AFFECTING RESPONSE PERSISTENCE

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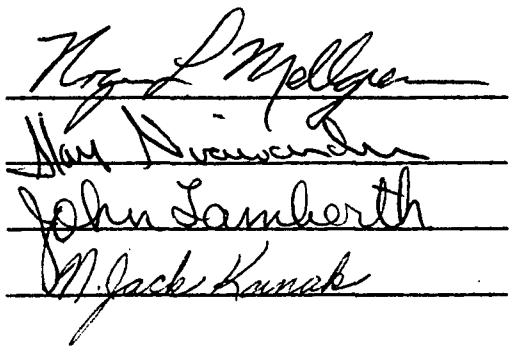

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TABLE OF CONTENTS

Punishment of Appetitively Reinforced Instrumental Behavior: Factors Affecting Response Persistence

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Abstract

In the first of two runway investigations, two groups of rats received partially punished, partial reinforcement training. Group PR received transitions from punishment to reinforcement (P-R transitions) whereas Group NR received transitions from nonreinforcement to reinforcement (N-R transitions), but both groups received the same number of P and N-trials. An additional group received unpunished continuous reinforcement training. Following training, the groups were split in half so that one half of the Ss in each group received punished extinction whereas the other half received unpunished extinction. The results indicated that Group PR was superior to Group NR in punished extinction and Group NR was superior to Group PR in unpunished extinction. The unpunished continuously reinforced controls performed the poorest regardless of the response decrement procedure employed. In the second experiment, Group NR and Group PR received a three phase within-S response decrement test procedure (unpunished, punished, and unpunished extinction). Generally, the results were consistent with those obtained in the first experiment, although several differences were noted. These results were interpreted in terms of E.J. Capaldi's (1967) sequential theory of instrumental learning.

Punishment of Appetitively Reinforced Instrumental Behavior: Factors Affecting Response Persistence

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It is a well established finding that partial punishment increases response persistence to continuous punishment over and above that produced by partial reinforcement (e.g., Banks, 1966a; 1966b; Brown & Wagner, 1964). Response persistence is increased more readily when punishment is administered on nonreinforced trials rather than on reinforced trials (Fallon, 1968; 1969), although persistence effects (relative to unpunished controls) have been observed in situations where punishment has been presented simultaneously with reinforcement (i.e., Banks, 1966b; Brown & Wagner, 1964).

Persistence effects due to punishment have traditionally been interpreted via an extension (Wagner, 1966) of Amsel's (1962; 1967) analysis of frustrative nonreward. However, recently several attempts have been made to extend Capaldi's (1967) sequential theory to account for the effects of punishment upon instrumental performance (Campbell, Crumbaugh, Marshall & Sparling, 1972; Campbell, Crumbaugh, Massey & Reed, 1972; Campbell, Wroten & Cleveland, 1973, Capaldi & Levy, 1972).

According to a sequential analysis, the mechanism of increased persistence depends upon the sequence of different goalbox events and not on "number" of such events per se (Capaldi & Kassover, 1970). In a partial reinforcement situation resistance to extinction is increased when nonreinforcement aftereffects (S^N) are conditioned to the instrumental response (R_I). Sequence is an important variable due to the fact that S^N is conditioned to R_I only on reinforced trials that have been preceded by nonrein-

forced trials.

Assuming that punishment results in a stimulus aftereffect (S^P), like S^N, it may be conditioned to R_I on reinforced trials that follow punished trials (P-R transitions). It follows that differential trial sequencing should produce differential response persistence. This hypothesis has been supported in two separate investigations (Campbell, et. al., 1973; Capaldi & Levy, 1972). In both studies it was found that response persistence was increased by partial punishment schedules containing P-R transitions relative to schedules containing only R-P transitions. Thus, preliminary evidence suggests that P-R transitions increase response persistence in a manner similar to N-R transitions.

The present experiments were designed to explore further the effects of sequential manipulations using both punishment and nonreinforcement. Accordingly, in the first of two experiments, two groups of Ss experienced partially punished, partial reinforcement training so that one group (Group PR) received P-R transitions and the other group (Group NR) received N-R transitions. A third group received continuous reinforcement (Group RR). It should be noted that both experimental groups received the same number of nonreinforcement-reinforcement-punishment events; only the trial sequence of these events was varied. Following training, the three groups were split in half so that one half of the Ss in each group received punished extinction and the other half received unpunished extinction. The unpunished extinction and punished extinction procedures will be referred to as response decrement procedures. It was hypothesized that differential group performance would be a function of the interaction between the type of training sequence and the kind of response decrement procedure used in testing. Specifically it was assumed that the stimulus complex in punished extinction

would be dominated by punishment stimuli (S^P) and therefore the Ss trained with theoretical S^P-R_I associations (Group PR) should be superior to Ss trained with theoretical S^N-R_I associations (Groups NR). Conversely, the opposite prediction was made for the Ss receiving unpunished extinction. That is, Group NR was expected to show greater persistence relative to Group PR in unpunished extinction (i.e., since unpunished extinction would occasion nonreinforcement related stimuli). Of course, Group RR was expected to show the least persistence, regardless of the response decrement procedure employed.

Experiment I

Method

Subjects. The Ss were 60 experimentally naive male albino rats of the Sprague-Dawley strain, purchased from the Holtzman Co. They were housed individually and were approximately 70 days old at the start of the experiment. The Ss were randomly assigned to one of three experimental groups (n=20/group).

Apparatus. The apparatus consisted of a single, straight alley runway manufactured by the Hunter Co. The alley was constructed of clear Plexiglas with a grid floor and was 150 cm long X 15 cm high X 9 cm wide. It was divided into a 30 cm start section, a 90 cm run section, and a 30 cm goal section; all sections being separated by guillotine doors. A teaspoon mounted in the middle of the far end of the goalbox served as a foodcup. The S's progress in the alley was measured by three .01 sec Standard timers. The first timer, which measured start time, was started by a microswitch at the startbox door and stopped by a photocell located 11 cm into the alley. The second timer, which measured run time, was started by the first photocell and stopped by a second photocell located 11 cm in front of the goalbox.

The third timer, which measured goal time, was started by the second photocell and stopped by a third photocell located 9 cm inside the goalbox. Start, run, and goal speeds were obtained by converting the start, run, and goal times to reciprocals. Total speeds were obtained by summing the start, run, and goal times and reciprocating this measure. Punishment consisted of a .3 mA scrambled shock which was gradually increased to .5 mA for 0.5 sec, administered in the goal section of the alley by a model 700 Grayson-Stadler shock generator. The shock was administered manually by pushing a button on the apparatus control panel.

Procedure. For 3 days after arrival in the laboratory, Ss were allowed free access to ad lib food and water. The Ss were then placed on a 12 gm. daily food deprevation schedule with water continuously available. The deprivation schedule was established 7 days before the start of the experiment. During the 3 days before the start of the experiment, each S was handled individually for 3 to 5 min. daily. Two days of pretraining preceded the experiment proper. On the first day all Ss received two reinforced trials and on the second day they received four continuously reinforced trials. The foodcup in the goalbox was baited on reinforced trials throughout the experiment with two 1 cm Purina Hog Starter pellets (approx. 90 mg. each).

Two groups received 66% reinforcement, 17% nonreinforcement and 17% punishment, and an additional group received 100% reinforcement. Group NR had all nonreinforced trials followed by reinforced trials; however, punished trials were never followed by reinforced trials. Group PR had all punished trials followed by reinforcement, whereas nonreinforced trials were never followed by reinforcement. Group RR received 100% reinforcement throughout training. Punishment was administered immediately after the S

broke the final photobeam. The goalbox was not baited on punished trials and the Ss were removed from the goalbox following punishment. The intensity of punishment was gradually increased from .3 mA to .5 mA in .1 mA increments during every fifth day of training. On nonreinforced trials, the Ss were confined in the goalbox for 15 sec.

Acquisition training lasted 15 days, 4 trials per day. The rats were run in squads of 6 with a 15-sec. intertrial interval. In order to prevent the Ss from forming a pattern discrimination, three different sequences were used during acquisition, each being used a total of five times. The three sequences of nonreinforced (N), reinforced (R), and punished (P) trials for Group NR were as follows: NRRR, RRRP, and NRRP. For Group PR the sequences were: RRRN, PRRR, and PRRN. Following acquisition, half of the Ss in each group received punished extinction and the other half of the Ss received unpunished extinction. Testing consisted of 20 trials, 5 days, 4 trials per day.

Results

Acquisition. Asymptotic performance was evaluated by analyzing the mean daily running speeds over the last 5 days of acquisition (20 trials). A 3(Group) X 2(Response Decrement) X 5(Days) repeated measures analysis of variance indicated nondifferential group performance as a function of training in start, F (2,54) = 1.76, $p > .05$; in run, F (2,54) = .38, $p > .05$; and in total, F (2,54) = 2.54, $p > .05$. The Group main effect did however account for a significant portion of the variance in the goal measure, F (2,54) = 9.64, $p < .01$. Post hoc comparisons (all comparisons reported in this and the subsequent experiment used the Scheffé correction procedure for post hoc comparisons) indicated that Group RR was superior to both Group PR and Group NR ($p < .01$). Unlike the acquisition data reported by Capaldi and Levy (1972), Groups PR and NR did not differ from

each other. The Response Decrement variable (extinction vs. punished extinction), which was a dummy variable for acquisition, was nonsignificant in all measures (all Fs < 1). The Days main effect was significant in start, F (4,216) = 6.10, $p < .01$; in goal, F (4,216) = 26.02, $p < .01$; and in total, F (4,216) = 8.68, $p < .01$; but not in the run measure, F (4,216) = 2.16, $p > .05$. None of the interactions in the analysis were significant. As the analysis indicated, very little response suppression was observed in Groups NR and PR relative to the continuously reinforced controls. It should be mentioned that at no time did any of the Ss in Groups NR or PR evidence patterning. Mean speeds across the last 5 days of acquisition are shown as Point A in Figure 1.

Insert Figure 1 about here

Response Decrement. A 3(Groups) X 2(Response Decrement) X 5(Days) analysis on the mean daily speeds indicated a significant main effect for Groups in start, F (2,54) = 19.47, $p < .01$; in run, F (2,54) = 46.21, $p < .01$; in goal, F (2,54) = 31.87, $p < .01$; and in total, F (2,54) = 50.59, $p < .01$. Post hoc comparisons showed that the PR groups were superior to the NR groups, and both were superior to the RR groups ($p < .01$ in all cases). The Response Decrement main effect (punished extinction vs. unpunished extinction) accounted for a significant portion of the variance in all sections of the alley, the smallest F being 22.15 in start (df = 1,54 in all cases). This finding reflects the fact that punished extinction produced greater response decrements than unpunished extinction. The most important finding was the significant Group X Response Decrement interaction, in start, F (2,54) = 8.20, $p < .01$; in run, F (2,54) = 11.12, $p < .01$; in goal, F (2,54) = 10.38, $p < .01$; and in total, F (2,54) = 14.40, $p < .01$.

Post hoc comparisons indicated that in punished extinction Group PR was superior to Group NR in all measures. On the other hand, Group NR was superior to Group PR in unpunished extinction in all measures ($p < .01$ in all cases), except in run where the two groups did not differ from each other. Of course, Group RR was inferior to all other groups regardless of the response decrement procedure employed. It is notable that in some sections of the alley Group PR performed as well in punished extinction as in unpunished extinction. In start and total measures, performance to the two response decrement procedures was nondifferential, however in the run and goal sections performance was better in unpunished extinction than in punished extinction ($p < .05$ in both cases). Both Group NR and Group RR were superior in unpunished extinction relative to punished extinction. Of course the Days main effect was highly significant in all sections. The F's for start, run, goal, and total were 55.16, 82.49, 91.29, and 124.34 respectively ($df = 4,216$ in all cases). The greatest decrement was noted in the goal section and the least in start with run showing intermediate suppression. Finally, the Groups X Days interaction was significant in all sections with the smallest F being in run, $F\ (8,216) = 3.33$, $p < .01$. This interaction is indicative that the groups extinguished at different rates. These effects for each of the alley segments across days are shown in Figure 1.

Discussion

The acquisition data reported here differs somewhat from previous research (Campbell, et. al., 1973; Capaldi & Levy, 1972) in that very little suppression was observed (only in the goal section). In both of the studies mentioned, suppression was substantial during training and the degree of suppression was dependent on the kinds of sequential transitions experienced.

It is likely that the lack of suppression in this experiment was due to the fact that punishment was administered on a sparse schedule (i.e., only 17% of the trials were punished). In addition, on every third day of training punishment was not given. It is notable that suppression, where observed, occurred in the goal section. Thus, that segment of the instrumental response chain occurring in the closest temporal and spatial proximity to punishment was suppressed, whereas earlier segments of the response were not. Evidence from a number of experiments (Campbell & Meyer, 1971; Capaldi & Levy, 1972; Capaldi & Ziff, 1969) provide support for the notion that mildly aversive stimuli in the goalbox produce differences between groups in the goal section, whereas more intense aversive stimuli produce group differences in the earlier segments of the runway. Presumably, differences in the start and run sections of the alley between the punished and unpunished groups would have been observed if punishment intensity and/or density had been increased in the present experiment.

The response decrement results obtained in the present experiment reflect the powerful influence of "sequence" in determining response persistence. More importantly, response persistence was shown to be a function of the interaction between the type of sequences used in training and the kind of response decrement procedure used in testing. Consistent with this prediction, it was found that Group PR was superior to Group NR in punished extinction, but the reverse was true in unpunished extinction. Thus P-R transitions increase response persistence relative to N-R transitions when testing is done with punishment related stimuli. Conversely, N-R transitions provide for greater persistence than P-R transitions when testing occurs with nonreinforcement related stimuli. This interaction is predicted by sequential theory following the assumption that persistence

to response decrement testing is increased by the similarity between stimuli conditioned to the instrumental response during training and the stimuli presented during testing (i.e., stimulus generalization decrement). Thus both Group PR and Group NR performed better when they received the same stimuli in testing that had been conditioned to the instrumental response during training, than when they were tested with stimuli not directly conditioned in training. It is noteworthy that in a similar experiment, Campbell, et. al. (1973) found that Ss trained with both N-R and P-R transitions were as persistent in unpunished extinction as Ss trained only with N-R transitions. A comparison of the present results with those reported by Campbell, et. al. (1973) illustrates how subtle variations in "sequence" can dramatically alter performance.

It is notable that Group PR was markedly superior to Group NR in punished extinction, but the superiority of Group NR over Group PR was less pronounced in unpunished extinction. In fact, the run measure did not reflect differential group performance in unpunished extinction. This finding may be interpreted by considering that punishment was administered on nonreinforced trials. For Group PR, subsequent reinforced trials may have resulted in the conditioning of a compound stimulus consisting of both nonreinforcement and punishment elements (S^N plus S^P) to R_I. Thus Group PR was provided with some degree of persistence to nonreinforcement related stimuli as well as to punishment related stimuli. This analysis also provides an explanation for the group main effect finding which showed Group PR to be more persistent than Group NR when the data were collapsed across the response decrement variable.

Experiment II

Although the data from Experiment I clearly reflects the powerful

influence of sequential manipulations in determining response persistence, it was felt that an additional experiment would provide additional information on the interaction between training sequence and response decrement procedure.

Thus, two groups were given training similar to that experienced by Group NR and Group PR in Experiment I. Following training, all Ss experienced a three phase response decrement test such that a period of punished extinction was administered between two periods of unpunished extinction.

Due to the brevity of the initial phase it was hypothesized that performance would be nondifferential. In the second phase (punished extinction) it was hypothesized that due to the instatement of punishment related cues, Group PR would be superior to Group NR. Finally, in the third phase of the test it was hypothesized that Group NR might be superior to Group PR. The third phase (unpunished extinction) was included to determine whether or not the reinstatement of S^N would produce increased performance in Group NR.

Method

Subjects. The Ss were 20 experimentally naive, male, albino rats of the Sprague-Dawley strain, purchased from the Holtzman Co. They were housed individually and were approximately 70 days old at the start of the experiment. The Ss were randomly assigned to one of two experimental groups (n=10/group).

Apparatus. The apparatus was identical to the one utilized in Experiment I.

Procedure. Acquisition training was carried out in the same manner as in Experiment I with the following exceptions: (a) training was extended to 112 trials, 4 per day, for 28 days and, (b) several additional sequences

were included to prevent Ss from forming a pattern discrimination. The additional sequences for Group NR were: RRNR and RNRP. For Group PR the additional sequences were: RRPR and RPRN. The percentage of nonreinforcement-reinforcement-punishment events was exactly the same as in Experiment I. Furthermore, it should be noted that on any given day all Ss experienced the same number of each kind of goalbox event.

Response decrement testing consisted of three phases: unpunished extinction, punished extinction and unpunished extinction, respectively. Testing consisted of 24 trials, 4 trials per day, for 6 days. Each of the three phases lasted for two days.

Results

Acquisition. The mean daily running speeds during the last 5 days of acquisition were analyzed by means of a 2(Group) X 5(Days) repeated measures analysis of variance. The differences between Group NR and Group PR were negligible at the end of acquisition training in start, goal and total measures (Fs < 1), although there was a nonsignificant trend for Group PR to be superior to Group NR in the run section, F (1,18) = 3.58, p > .05. The Days main effect accounted for a significant portion of the variance in run, F (4,72) = 5.09, p < .01; in goal, F (4,72) = 10.19, p < .01; in total, F (4,72) = 4.83, p < .01; but not in start, F (4,72) = 1.88, p > .05. Finally the interaction did not approach significance in any of the runway sections, the largest F being in total, F (4,72) = 1.69, p > .05.

Response Decrement: Phase I (Unpunished Extinction). A 2(Group) X 2(Days) repeated measures analysis of variance, performed on the mean daily running speeds, indicated a nonsignificant main effect for Groups in all runway measures: F's = .01, .69, 1.06 and .55 in start, run, goal and total sections, respectively (all df = 1,18). The Days main effect was significant

at the .01 level or better in all measures, the smallest F being 9.23 in start (all df = 1,18). The Groups X Trials interaction was negligible in all runway measures (F's < 1 in most sections). Thus the first phase of the response decrement test produced a nondifferential decline in response speed.

Response Decrement: Phase II (Punished Extinction). A 2(Group) X 2(Days) analysis, indicated a significant main effect for Groups in start, F (1,18) = 5.46, $p < .05$; in run, F (1,18) = 11.02, $p < .01$; in goal, F (1,18) = 5.93, $p < .05$; and in total, F (1,18) = 8.06, $p < .01$. The Days main effect was significant in all segments of the runway with the smallest F being in start, F (1,18) = 39.03, $p < .01$. The Group X Days interaction did not account for a significant portion of the variance in any of the runway sections. The major finding was that Group PR was statistically superior to Group NR in punished extinction, consistent with the finding in Experiment I. In order to examine this finding more closely a 2(Group) X 4(Trials) analysis was performed on the running speeds of the four punished trials on each of the two days of punished extinction. The analysis on the first day of punished extinction showed that the Group main effect was significant in all runway measures: in start, F (1,18) = 5.67, $p < .05$; in run, F (1,18) = 13.35, $p < .01$; in goal, F (1,18) = 8.36, $p < .01$; and in total, F (1,18) = 10.19, $p < .01$. The Group X Trials interaction also accounted for a significant portion of the variance in start, F (3,54) = 2.92, $p < .05$; in run, F (3,54) = 3.13, $p < .05$; and in total, F (3,54) = 5.87, $p < .01$; but not in goal, F (3,54) = 1.29, $p > .05$. Post hoc comparisons indicated that on the first punished trial the performance of the two groups was nondifferential. However, Group PR was superior to Group NR on the second trial (all ps <.01) and all succeeding trials. Thus the superi-

ority of Group PR over Group NR was evidenced after the administration of only one punished trial. Of course, the Trials main effect was significant in all runway measures. On the second day of punished extinction a pattern of results similar to the first day was observed except that performance was slower and therefore the magnitude of the group differences was smaller. The Group main effect was reliable in start, F (1,18) = 4.56, $p < .05$; in run, F (1,18) = 7.81, $p < .05$, but not in goal, F (1,18) = 3.49, $p > .05$; and total, F (1,18) = 4.19, $p > .05$. The Group X Trials interaction was statistically significant in start, F (3,54) = 4.04, $p < .05$; in run, F (3,54) = 7.14, $p < .01$; and in total, F (3,54) = 2.91, $p < .05$; but not in goal, F (3,54) = 2.56, $p > .05$. Appropriate post hoc comparisons (on start, run, and total data) indicated that on the first punished trial group performance was nondifferential, however by the second trial Group PR was superior to Group NR ($p < .01$ in all cases, with the exception of goal). The trial by trial performance of the groups during the two days of punished extinction is shown in Figure 2. An inspection of the graphs on the second day of punished extinction indicates that Group PR actually ran faster on the second trial than on the first trial. This effect was statistically reliable in both the start and run sections ($p < .05$ and $p < .01$, respectively). On the other hand it can be seen that Group NR ran reliably slower on the second trial of both punished extinction days ($p < .01$ in all cases). A related finding was that the groups performed nondifferentially on the first trial of each day thereby indicating that spontaneous recovery was not differently affected by the treatment variables.

Insert Figure 2 about here

Response Decrement: Phase III (Unpunished Extinction). A 2(Groups) X

2(Days) analysis on the mean daily running speeds revealed a significant Group main effect in run, F (1,18) = 4.72, $p < .05$; in goal, F (1,18) = 7.19, $p < .05$; and in total, F (1,18) = 4.89, $p < .05$; but not in start, F (1,18) = 3.32, $p > .05$. Group PR maintained its superiority over Group NR despite the fact that nonreinforcement stimuli were reinstated in the goalbox without punishment. The Trials main effect accounted for a significant portion of the variance only in the start measure, F (1,18) = 12.15, $p < .01$. This indicates that the Ss had reached asymptotic extinction. The Group X Trials interaction was negligible in all runway sections (most F's < 1).

Discussion

The response decrement findings in Experiment II are generally consistent with the results of Experiment I. Following a block of unpunished extinction trials (Phase I) in which performance was nondifferential, the sudden introduction of punishment produced dramatic between group performance differences (Phase II). These differences were nonexistent on the first punished trial but appeared in robust form on following trials. The sudden superiority of Group PR over Group NR in punished extinction indicates that stimulus control (i.e., the capacity of S^P to occasion R_I) of punished reactions is maintained through a block of unpunished extinction trials.

In contrast, the data obtained in the final phase of unpunished extinction did not conform to prediction. It was hypothesized that the reinstatement of S^N would result in increased performance for Group NR and decreased performance for Group PR. This hypothesized interaction did not occur; rather both groups seemed to reach asymptotic extinction performance with Group PR still running significantly faster than Group NR.

Several possibilities may be considered to account for the Phase III data. First, it is possible that proactive interference occasioned by Phase II punishment resulted in the disruption of the S^N-R_I association for Group NR. This is a plausible assumption, but it is not immediately clear why unpunished extinction (Phase I) did not proactively interfere with Phase II performance for Group PR. A second possibility to account for the poor performance of Group NR in Phase III is that nonreinforcement produced stimuli are simply not as distinctive as punishment produced stimuli and therefore stimulus control established with S^N dissipates or is disrupted more readily than stimulus control established with S^P. Finally, it is possible that Phase III performance merely reflects the S's ability to recover from the effects of response contingent punishment. Group PR had reinforcement associated with the aftereffect of punishment during training whereas Group NR did not; consequently S^P may have been psychologically more intense for the latter Ss. If S^P was a more "intense" event for Group NR relative to Group PR, poorer recovery for the latter group would be expected. There is evidence (Boe & Church, 1967) that recovery from punishment does not occur (when punishment is delivered at the beginning of extinction) at a wide range of punishment intensities; with the extent of suppression being inversely related to punishment intensity. In summary, it is possible that a combination of the factors mentioned is responsible for the poor performance exhibited by Group NR in Phase III.

General Discussion

These experiments suggest that the trial sequencing of partial punishment, partial reinforcement training controls performance during response decrement testing. Furthermore, the level of performance depends not only on the trial sequence of nonreinforcement-reinforcement-punishment events

in training, but also upon the kind of response decrement procedure that is used during testing. The greatest persistence is observed when the testing stimuli are identical to the stimuli conditioned to instrumental behaviors in training. Thus, Group PR was more persistent than Group NR in punished extinction whereas the reverse was true in unpunished extinction.

In the second experiment, after an interpolated block of unpunished extinction, it was again shown that Group PR was superior to Group NR in punished extinction. The converse relationship (i.e., Group NR superior to Group PR in unpunished extinction) was not observed when unpunished extinction was preceded by blocks of unpunished and punished extinction trials. Thus a within-S response decrement comparison produces somewhat different results than a between-group comparison.

These data confirm and extend the results of Campbell, et. al. (1973) and Capaldi and Levy (1972) and lend further support to the notion that "sequence" is a crucial determinant of response persistence. It appears that P-R transitions function in a manner analogous to N-R transitions. However, the theoretical similarity between nonreinforcement and punishment could be extended even further if effects analogous to those obtained in partial reinforcement-extinction situations were demonstrated using punishment.

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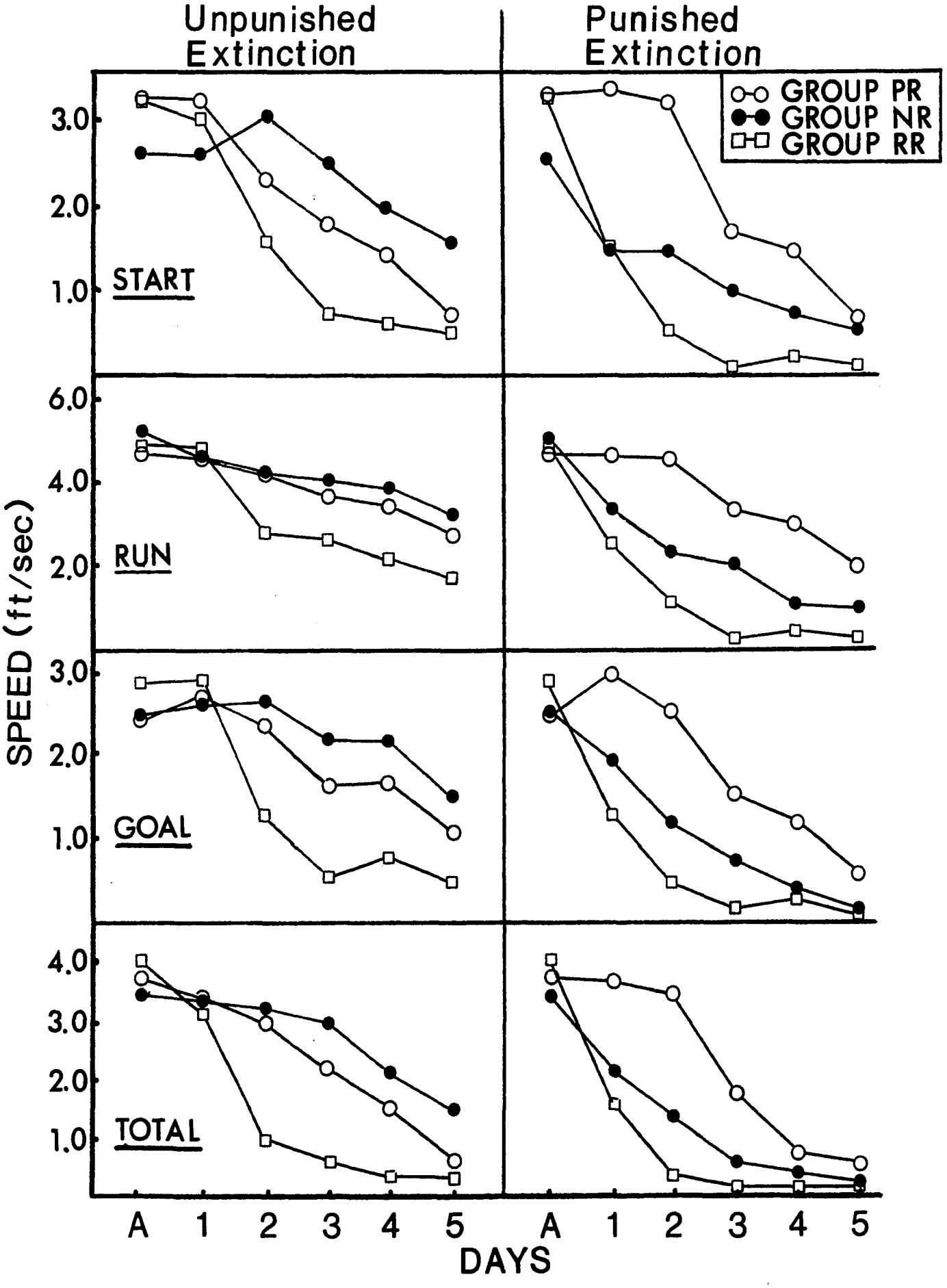
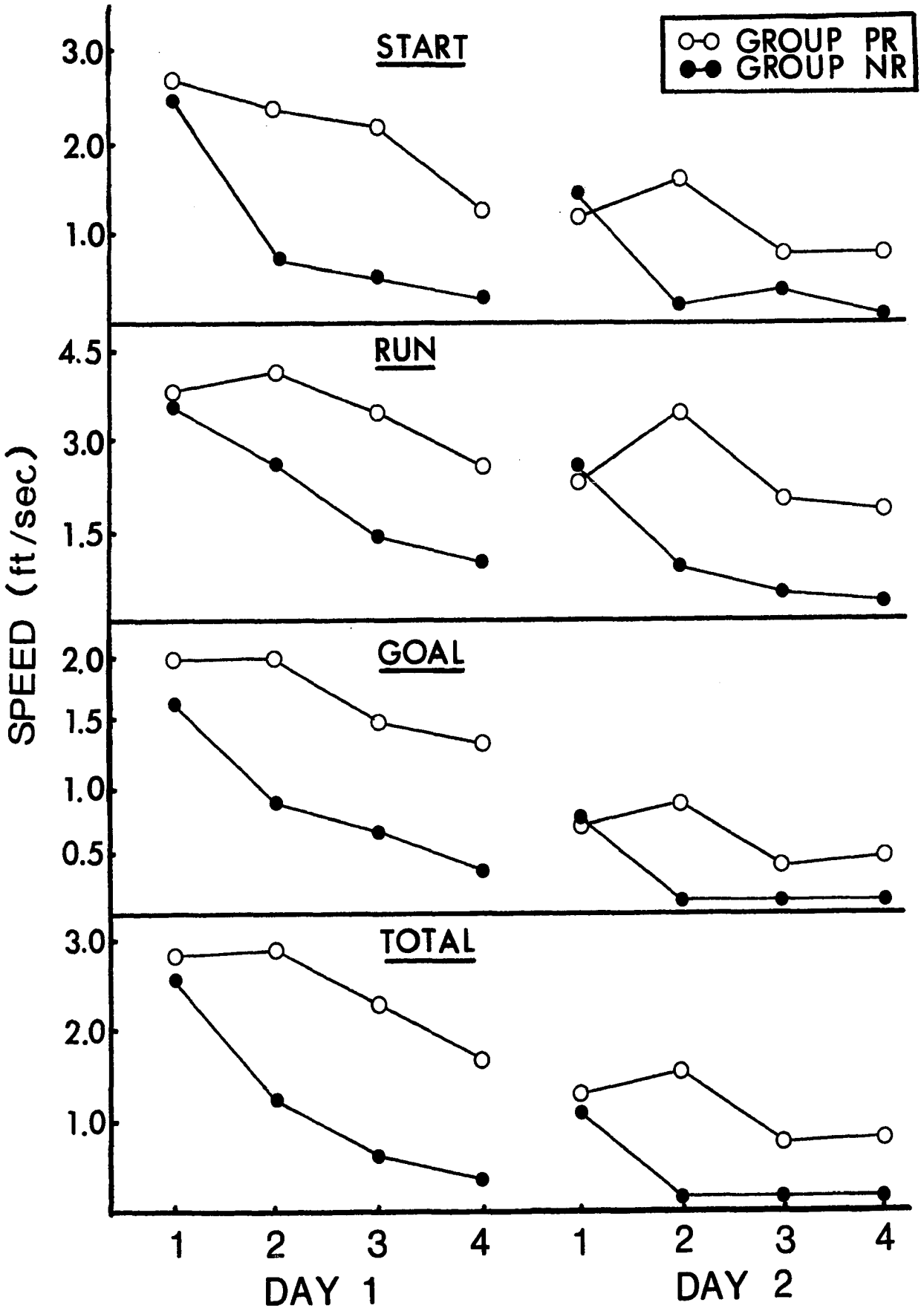
Figure Captions

Fig. 1 Mean running speeds for the last day of acquisition (A) and five days of punished and unpunished extinction for all of the runway measures.

Fig. 2 Mean running speeds for the two days of punished extinction for all of the runway measures.


Unpunished Extinction
Punished Extinction
GROUP PR
GROUP NR
GROUP RR
START
RUN
GOAL
TOTAL
SPEED (ft/sec)
3.0
2.0
1.0
6.0
4.0
2.0
3.0
2.0
1.0
4.0
3.0
2.0
1.0
A 1 2 3 4 5
A 1 2 3 4 5
DAYS


START
RUN
GOAL
TOTAL
GROUP PR
GROUP NR
SPEED (ft/sec)
3.0
2.0
1.0
4.5
3.0
1.5
2.0
1.5
1.0
0.5
3.0
2.0
1.0
1 2 3 4 1 2 3 4
DAY 1
DAY 2

APPENDIX A

PROSPECTUS

PUNISHMENT OF APPETITIVELY REINFORCED INSTRUMENTAL BEHAVIOR:

FACTORS AFFECTING RESPONSE PERSISTENCE

The punishment procedure refers to the presentation of an aversive stimulus contingent upon a response (Church, 1963). The principal effect of this procedure is to suppress the punished response. There is a large body of literature however, that indicates that the suppressive effects of punishment may be enhanced, concealed, or even overridden by the context in which punishment is administered. The purpose of this paper is to selectively review the available literature on punishment of appetitively based instrumental behavior in order to delineate the conditions that regulate relative persistence to the decremental effects of punishment. This involves an analysis of experimental situations in which training is based upon positive reinforcement (except where procedures have particular relevance to the problem at hand), and specifically omits behaviors based upon negative reinforcement (escape and avoidance). Following a review of available data, several theoretical interpretations will be described. Finally, several studies will be proposed that test assumptions derived from an extension of Capaldi's (1966; 1967; 1970) sequential theory of instrumental learning.

In order to facilitate communication, the terminology adopted by Church (1963) will be used in this paper. Regular training refers to a procedure in which only a positive reinforcer is administered following a response. Punishment training refers to a procedure in which both a positive reinforcer and a punishing stimulus occur contingent upon the response. Similarly, punished extinction refers to a procedure whereby each response is punished but not positively reinforced and unpunished extinction refers

to a procedure whereby neither a punishing stimulus nor a positive reinforcer is administered. Finally, the present review will distinguish between experiments employing a free responding operant procedure as opposed to a discrete trials instrumental procedure.

Discrete Trials

Regular Training Preceding Punishment

A number of studies have assessed the effect of prior experience with positive reinforcement upon performance to subsequent punishment. These experiments may be characterized as separate phase experiments involving a prior phase of positive reinforcement, and a subsequent phase of either punishment training, punished extinction, or unpunished extinction. A variety of reinforcement parameters have been manipulated in order to determine their influence on resistance to subsequent punishment. Studies involving unpunished extinction after a period of regular training have been extensively reviewed(Robbins, 1971). Only passing mention will be made of these studies where they are conceptually related to procedures involving punishment training or punished extinction in phase 2.

Magnitude of Reinforcement.--Ferraro (1966) was able to show that resistance to punishment training was inversely related to the magnitude of reinforcement prior to punishment. Four groups of rats were trained to bar press in a discrete trials situation for .01, .02, .04, or .08 cc of water reinforcement on a continuous reinforcement schedule. Following 600 regular training trials, a .25 mA shock of .5 sec duration was administered following each response, in addition to water reinforcement. The results clearly indicated that performance during punishment training was less disrupted as prepunishment, reinforcement magnitude decreased.

Similarly, Ratliff, Koplin and Clayton (1968) trained Ss with 8 or 1 food pellets in a runway and found that the Ss trained with 8 pellets were inferior to the Ss trained with 1 pellet during a subsequent punished extinction phase. These data are consistent with studies in which regular training is followed by unpunished extinction (e.g., Hulse, 1958; Wagner, 1961). It should be noted that these findings contrast with an earlier separate phase experiment by Bower and Miller (1960) in which the tendency to approach in an approach-avoidance conflict (positive reinforcer and punishing stimulus in goal box) was found to be an increasing function of the magnitude of the positive reinforcer in the goal box. Procedurally, the Bower and Miller (1960) experiment differs from the more recent studies in that the shock level was gradually increased during testing, and it is possible that this could account for the discrepant data.

Number of Reinforced Trials.--The number of reinforced trials has been shown to regulate performance to subsequent punishment training. Lawson and Born (1964) gave different groups of Ss from 200 to 3,000 reinforced trials. Following regular training, the Ss were punished until they met a criterion of suppression. The following day the latency of the first response was recorded. The results indicated that latency decreased with increasing number of reinforced trials prior to punishment up to 1,000 trials, but for greater numbers of reinforced trials suppression latencies increased. These data imply that the relationship between number of reinforced trials and recovery from subsequent punishment, may be curvilinear. These data are generally consistent with those obtained when unpunished extinction is given following regular training (c.f. Sperling, 1965).

Percentage of Reinforcement.--In a factorial design, Ratliff and

Clayton (1969) combined four levels of reinforcement percentage during regular training (25, 50, 75, and 100%) with three levels of punishment intensity during punished extinction (0,.8, and 1.6 mA). Except for the most severe condition in punished extinction (i.e., 1.6 mA), the percentage of reinforcement was inversely related to persistence of performance during punished extinction. Similarly, Vogel-Sprott (1969) employing human Ss found that partial reinforcement produced greater resistance to punishment training and subsequent unpunished extinction than did continuous reinforcement training. The above findings have been confirmed (Berkun, 1957; Brown & Wagner, 1964) thereby supporting the generalization that percentage of reinforcement and resistance to subsequent punishment are inversely related.

Thus reinforcement parameters such as magnitude and percentage have generally been shown to vary inversely with resistance to subsequent punishment training and unpunished extinction. The relationship between resistance to punishment training and number of reinforced trials is less well understood, although the data gathered thus far indicates that the relationship may be curvilinear.

Intensity of Punishment.--The degree of suppression produced by punishment is a monotonically increasing function of the level of intensity of the punishing stimulus (Fowler, 1963; Karsh, 1962; 1963; 1964a) In a representative study, Karsh (1962) trained Ss to run to food during 75 training trials. Then each S received one trial per day for 40 days with both food and shock in the goal box (punishment training). The levels of shock intensity for the various groups were 0, 75, 150, 300 and 600 volts for 100 milliseconds administered through 250,000 ohms resistance in series with the rat. The results showed that the group receiving 75 volts

did not differ from the controls (0 shock condition). The Ss receiving 300 and 600 volts punishment showed complete cessation of running within a few trials. The 150 volt group was suppressed at an intermediate level but did not cease to respond. In another study, (Fowler, 1959) it was found that at mild intensities of punishment, Ss either increased or decreased their running speeds. Evidence was presented that Ss increasing their speed had skeletal responses elicited which were compatible with running, while Ss decreasing their speed had incompatible skeletal responses elicited.

Trial Spacing.--Several studies have parametrically investigated punishment intensity and trial spacing (Fowler, 1963; Karsh, 1964b). Generally, these studies have found that spaced trials produce greater resistance to punishment training relative to massed trials at a wide range of intensities.

Contingent Punishment Training

We will now turn to those studies in which response contingent punishment training occurs in the context of positive reinforcement and precedes some form of response decrement testing (e.g., more severe punishment, punished extinction). In the training phase of these studies punishment and reinforcement events may be administered either continuously or intermittently and consequently in our review a distinction with regard to schedule will be made. These procedures may be classified as mixed phase since both the punishing stimulus and positive reinforcer are present in the first phase of the experiment.

Continuous Reinforcement-Continuous Punishment.--In the reference study, Miller (1960) found that Ss trained to approach and consume food (continous reinforcement) in the presence of gradually increasing, continu-

ous punishment were more resistant to the effects of subsequent intense punishment than control Ss that did not receive prior experience with punishment. Response persistence was not enhanced when prior punishment training occurred in an apparatus different from the one used in testing. In addition, it was found that prior experience with continuous punishment was less effective in producing persistence to subsequent intense punishment if the manner of introduction was sudden rather than gradual. A number of studies have replicated the findings of Miller (1960) in runway investigations (Martin, 1963; Martin & Ross, 1964), and in a discrete trials bar pressing situation (Karsh, 1964a; 1966). Church (1969) also reports that the same general findings are observed when duration of the punishing stimulus (rather than intensity as measured by volts or mA) is gradually increased. That is, Ss trained to respond for food in the presence of a punishing stimulus of increasing duration are more persistent to the effects of subsequent long-duration punishment, relative to control Ss which received the long duration with no prior punishment training.

Continuous Reinforcement-Partial Punishment.--Prior exposure to partial punishment in the context of continuous reinforcement has been shown to increase persistence to continuous punishment training (Banks, 1966) and unpunished extinction (Brown & Wagner, 1964; Logan, 1960; Martin & Ross, 1964). In these investigations, the punishing stimulus was introduced both intermittently and gradually during training. The finding that partial punishment increases response persistence to subsequent response decrement procedures has been termed the intermittent punishment effect (IPE). The IPE appears robust when testing with continuous punishment training but is less reliable when testing with unpunished extinction.

Partial Reinforcement-Partial Punishment.--The majority of investigations employing a partial punishment training procedure have superimposed punishment on partial reinforcement schedules. For example, Banks (1966) trained three groups of Ss on a 70% partial reinforcement schedule. One group experienced punishment on all nonreinforced trials. A second group was treated identically except that punishment was administered in a separate compartment. An additional control group was given partial reinforcement training without any punishment. All groups were subsequently shifted to punished extinction. The results showed that the intermittent punishment group was superior to the group that had received punishment training in a separate compartment. Both groups receiving punishment training in the first phase were superior to the unpunished partial reinforcement control group in punished extinction. These data clearly indicate that partial punishment produces persistence effects to punished extinction over and above that obtained with partial reinforcement training. Kinler and Banks (1969) replicated the above finding with the inclusion of an additional control group that received partial punishment training via placements (i.e., the S was placed in the goal box and shocked on punished trials with no positive reinforcement present) in the training and testing apparatus. This placement group received the same frequency, intensity, duration, and locus of punishment as the experimental group but was reliably inferior to the group receiving intermittent punishment following the instrumental running response. These data indicate that punishing a response may increase the persistence of that response, and that the locus of this effect is not due to the relationship between environmental stimuli and the punishing stimulus, but is due to the response being punished. That is, persistence to punishment is in-

creased only when the S makes an approach response in the presence of punishment cues. Unfortunately, this interpretation of Kinler and Banks (1969) must be regarded with some caution due to the large number of placements (30) that were given. It has been observed in partial reinforcement situations that placements lose their effectiveness when large numbers are given (e.g., Black & Spence, 1965) due to the fact that Ss learn to discriminate placement trials from running trials (Capaldi, 1967).

In a parametric investigation, Uhl (1967) simultaneously manipulated percentage of reinforcement (50 or 100%) and percentage of punishment (0, 50, or 100%) during the acquisition of a discrete trials bar pressing response. Following training the groups were split in half such that one half of each group experienced unpunished extinction and the other half experienced punished extinction. Performance in both unpunished and punished extinction was enhanced by increasing the percentage of punishment in training. Conversely, performance in extinction (unpunished and punished) decreased as a function of increasing percentage of reinforcement. Scull (1971) trained Ss to run for food on either a partial or a continuous reinforcement schedule. Then each group was split in half and given either 50% shock or 50% noise punishment in addition to the existing schedule of reinforcement. Finally, all groups were given unpunished extinction. The data indicated that the groups receiving partial reinforcement were more resistant to extinction relative to the continuously reinforced groups, regardless of the kind of punishing stimulus employed. No differential extinction performance was observed due to kind of punishment employed in training.

Locus of Punishment.--There has been considerable interest in the differential effects of punishment administered on nonreinforced versus

reinforced trials when behavior is both partially reinforced and partially punished. When punishment occurs exclusively on reinforced trials, Ss perform better than when punishment is given only on nonreinforced trials in acquisition (Scull & Vechseler, 1972); however the reverse is true in punished extinction (Fallon, 1968; 1969).

Scull and Vechseler (1972) gave two groups of Ss 50% reinforcement and 50% punishment in a runway situation. One group received punishment on reinforced trials while the other received punishment on nonreinforced trials. An additional control group experienced 50% partial reinforcement without punishment. Both punished groups were inferior to the unpunished control group. More importantly, the Ss receiving punishment on reinforced trials ran faster and retraced less than Ss experiencing punishment on nonreinforced trials. Unfortunately, the authors did not collect extinction data.

Fallon (1968; 1969) has reported that performance during unpunished and punished extinction is increased when, during training, punishment is administered on nonreinforced rather than on reinforced trails. In the initial study (Fallon, 1968), four groups of rats were trained to bar press for liquid saccharin reinforcement. Three groups received 50% positive reinforcement and 50% punishment for the consummatory licking response so that punishment occurred on (a) nonreinforced trials (licking a dry cup), (b) reinforced trials (licking a wet cup), or (c) equally often on both nonreinforced and reinforced trials. A fourth group received 50% partial reinforcement without punishment. Half of the Ss in each group were shifted to unpunished extinction whereas the other half was shifted to punished extinction. The acquisition data indicated that all the groups receiving punishment were inferior to the unpunished controls. Furthermore,

there was a trend (nonsignificant) for Ss receiving punishment on nonreinforced trials to be inferior to Ss receiving punishment on reinforced trials, consistent with Scull and Vechseler (1972). The unpunished extinction data indicated that the Ss receiving punishment equally often on nonreinforced and reinforced trials were superior to the Ss in all other groups, which did not differ from each other. In punished extinction, the groups receiving punishment on nonreinforced trials or on both nonreinforced and reinforced trials were superior to the groups receiving punishment on reinforced trials and the unpunished controls. Neither the first two nor the last two groups differed from each other. In a subsequent experiment (Fallon, 1969), these results were replicated supporting the conclusion that the locus of the increased persistence was produced by administering punishment on nonreinforced trials. The discrepancy between acquisition data (Scull & Vechseler, 1972) and extinction data (Fallon, 1968; 1969) is difficult to resolve and further research in this area is clearly needed.

In a recent double runway investigation (Fallon, 1971) rats were given various conditions in the first goal box. Three groups received only food (100% large reward, 50% large reward, and 100% small reward) and a fourth group received 100% large reward plus 50% punishment. All groups received continuous reinforcement in the second goal box. Fallon hypothesized that punishment occurring on reinforced trials may reduce the effective reward magnitude on those trials. Thus it was expected that the Ss receiving punishment in this investigation would perform similarly to Ss experiencing small reinforcement. In the second segment of the double runway the punished group performed similarly to the group receiving small reinforcement. Both the punished Ss and the small reinforcement Ss showed

a very weak frustration effect relative to those Ss receiving large partial reinforcement. Furthermore, when responses in the first segment of the double runway were extinguished, the punished group was superior to the large continuously reinforced group but did not differ from the group that received small continuous reinforcement. Thus a group experiencing continuous reinforcement plus partial punishment performs like a group receiving small continuous reinforcement. Of course, when punishment is administered on nonreinforced trials there is no hypothesized reduction of reward because reward is already zero. Therefore, a comparison between groups receiving punishment on nonreinforced trials with groups receiving punishment on reinforced trials may be functionally analogous to a comparison between groups trained with large and small partial reinforcement, respectively. According to this analysis, punishment of nonreinforced trials would be expected to produce greater response persistence than punishment on reinforced trials as was found (i.e., training with large partial reinforcement produces greater resistance to extinction than does training with small partial reinforcement, Hulse, 1958). It should be noted that Fallon's (1971) analogy breaks down slightly in that the punishment group received 50% punishment and therefore reinforcement was hypothetically reduced only on 50% of the trials. Thus the effective schedule was a varied magnitude of reward schedule. Varied magnitude of reward schedules have been shown to produce greater resistance to extinction relative to consistent small reward schedules (c.f. Capaldi, 1967; 1970; Leonard, 1968). Also, if punishment reduces effective reward magnitude it would be expected that punishment on reward trials would tend to reduce running speed during acquisition relative to punishment on nonreward trials--exactly opposite to Scull and Vechseler (1972).

Although the theoretical interpretation of Fallon's (1968; 1969; 1971) data is open to question (especially considering the doubts of the theoretical interpretation of the frustration effect in the double runway, DiLollo & Allison, 1972), the empirical finding that punishment on nonreinforced trials increases response persistence is clear. Several recent experiments have sharpened this empirical generalization to an even greater extent and have provided a more solid theoretical footing to account for the finding. These investigations deriving from sequential theory (Capaldi, 1966; 1967; 1970) involved the administration of punishment on nonreinforced trials, but varied the occurrence of reinforced trials following punishment (Campbell, Wroten & Cleveland, in press; Capaldi & Levy, 1972).

The procedure employed by Campbell et al (in press) involved 16 days of partial reinforcement training. During the final 12 days, experimental Ss received one punished trial per day. One group received reinforced trials following punished trials (P-R transitions). A second group received punished trials following reinforced trials (R-P transitions), but reinforced trials were never allowed to follow punished trials. An additional group received punishment after completing all daily trials. Following training, the Ss in each group were split so that half received unpunished extinction and the other half received continuously punished, partial reinforcement. During continuous punishment the group receiving P-R transitions was superior to the other groups which did not differ. During punished extinction, the group receiving P-R transitions and the control group did not differ, but both were superior to the group receiving R-P transitions. In the first of two experiments, Capaldi and Levy (1972) replicated the findings of Campbell et al (in press) and extended the generality of those findings to punished extinction. In the second experi-

ment it was found that persistence could be enhanced by increasing the reinforcement magnitude on trials following punishment (nonreinforced punishment). Conversely, increasing magnitude of reinforcement on trials preceding punishment had the opposite effect. In this experiment groups received large (L) and small (S) magnitudes of reward on trials preceding and/or following punished (P) trials. Schematically, the four groups may be represented as follows: LPL, SPL, LPS, and SPS. Both acquisition and punished extinction performance was superior in Groups SPL and LPL relative to Groups LPS and SPS. Furthermore, the performance of Group SPL was superior to Group LPL in punished extinction. Thus increasing reinforcement magnitude on trials preceding punishment decreased persistence to punished extinction, but increasing reward magnitude on trials following punishment increased persistence, a result consistent with data involving nonreinforcement rather than punishment (Eckert & Mellgren, 1973; Leonard, 1968; Mellgren, Dyck, Seybert & Wrather, 1973). Furthermore, the effects observed by Capaldi and Levy (1972) obtained when the ordinal position of punishment was controlled.

The Generality of Punishment Persistence Effects

The empirical finding that punishment administered appropriately, produces increased response persistence to subsequent punishment stimuli has led investigators to explore the generality of punishment persistence effects. In this regard there has been considerable interest in demonstrating that training with one punishment stimulus generates persistence not only to that stimulus in subsequent testing, but also to quantitatively and qualitatively different punishing events. Of particular concern has been an assumed commonality between the consequences of nonreinforcement and punishment (Berkun, 1957; Brown & Wagner, 1964; D'Amato, 1969; Ratliff,

Koplin & Clayton, 1968; Tsushima, 1959; Wagner, 1966; 1969). Much of the interest regarding the generalization between nonreinforcement and punishment has derived from Amsel's (1962; 1967; 1972) frustration analysis of persistence. Investigators have not only attempted to show that punishment effects generalize between different punishing stimuli but in addition, have attempted to demonstrate that persistence will generalize from one experimental context to another (transituational persistence).

Generalization to Different Punishers.--Terris and Rahhal (1969) found that a group of rats trained to approach and consume food in the presence of shock punishment were subsequently more resistant to the effects of airblast punishment than a nonshock control group. In another study, Terris and Barnes (1969) trained different groups to approach and consume food in the presence of increasing shock, increasing airblast, or no punishment. The groups were then split and tested with intense shock or intense airblast punishment. It was found that the shock trained groups were more resistant to the effects of both intense shock and intense airblast than the unpunished controls; however the airblast trained groups were resistant only to the effects of intense airblast but not to the intense shock punishment. This implies that there is generalization from shock to airblast punishment but not from airblast to shock. These data are contradicted by earlier work in which the generalization between shock and airblast punishment was complete (Terris & Wechklin, 1967). In another relevant study, Banks and Torney (1969) showed that intermittent punishment training with one shock intensity (.3 mA) increased performance to continuous punishment of a greater intensity (.6 mA). Furthermore, the IPE was observed, although weakly, when a tail pinch was used in testing. Interestingly, the IPE was not observed when testing consisted of unpunished

extinction. In general, the data from these experiments suggest that punishment persistence effects generalize to other punishment stimuli when training has been with shock punishment. When training with punishment stimuli other than shock there is little support for the generalization of persistence.

Generalization between Punishment and Nonreinforcement.--The assumption that nonreinforcement and punishment have common emotional consequences led Brown and Wagner (1964) to posit that experience with nonreinforcement should lead to increased resistance to punishment relative to continuously reinforced controls and experience with punishment should lead to increased resistance to unpunished extinction, relative to continuously reinforced controls. Accordingly, three groups of rats were trained such that one group (Group N) received 50% partial reinforcement; a second group (Group P) received 50% partial punishment along with continuous reinforcement; and a third group (Group C) received continuous reinforcement and no punishment. Half of the Ss in each group were tested with unpunished extinction and the other half was tested with continuous punishment training. It was found, as hypothesized, that Group P and Group N were more persistent not only to the decremental variable (punishment or nonreinforcement) with which they had been trained, but also to the alternate test variable, relative to Group C. Furthermore, Group P was superior to Group N in continuous punishment whereas the reverse was true in unpunished extinction. These data provide strong support for the generalization of persistence between nonreinforcement and punishment. The Brown and Wagner (1964) results have been replicated, at least in part, by experiments reviewed earlier in which regular training preceded punishment (e.g., Ratliff & Clayton, 1969; Vogel-Sprott, 1969).

Transituational Generality.--In an attempt to demonstrate that punishment persistence effects can be produced even when training and testing occur in different experimental contexts, Banks (1967) first trained Ss to approach and consume food in the presence of intermittent shock in a short, wide apparatus. Control Ss received shock punishment in a separate apparatus. Then all Ss were continuously reinforced with water for running in a long narrow runway. Finally, all groups received punishment training in the long narrow runway. The results showed that the Ss receiving intermittent punishment training were more persistent to punishment training (continuous punishment) than the Ss receiving control shocks. Thus the IPE was observed through changed stimulus conditions and through a block of nonpunished continuously reinforced trials.

In a study investigating both the generality and transituationality of punishment persistence effects, Terris and German (1969) trained Ss to approach and consume food in the presence of partial reinforcement, partial punishment, or continuous reinforcement in a modified operant conditioning chamber. Testing with punished or unpunished extinction was conducted in a straight alley runway. In punished extinction, the performance of Ss trained with partial punishment was superior to that of Ss trained with partial or continuous reinforcement. The latter two groups did not differ from each other. On the other hand, when unpunished extinction was the decremental variable no performance differences between any of the groups was observed. These data indicate that generalization between nonreinforcement and punishment may be limited if training and testing are performed in different contexts. Transituational persistence due to punishment was observed in punished extinction; however the corresponding effect with partial reinforcement was not observed in unpunished

extinction. The latter finding is somewhat mystifying, especially in light of results such as those reported by Ross (1964) in which a transituational partial reinforcement effect was obtained. In a related study, Terris, German and Enzie (1969) found that Ss trained to approach and consume food in the presence of shock punishment in a runway were subsequently more persistent to both shock and airblast in their homecages while eating (measured by latency to return eating after the offset of the aversive stimulus). These data indicate that learned resistance to punishment generalizes to novel punishment stimuli (airblast) in novel testing situations.

The most impressive array of evidence for generalized persistence in transituational experiments comes from a series of recent studies by Amsel, Wong and Scull (1971) and Wong (1971a; 1971b). Of particular interest is the fact that punishment training in these experiments, was administered in the absence of reinforcement.

In the Amsel, Wong and Scull (1971) study, two groups of chicks were given imprinting experience with or without shock punishment. An additional two groups received no imprinting experience with or without shock experience. Then the Ss in each group were split in half so that one half of the Ss received 50% partial reinforcement or 100% continuous reinforcement for running in a straight alley runway. Finally, the running response was extinguished (unpunished extinction). The results showed a partial reinforcement extinction effect for all groups, regardless of the type of training received in the original phase of the experiment. More importantly, the Ss that had experienced imprinting in the presence of shock punishment were superior to all other Ss. These data imply that persistence effects may be produced when a response compatible with running (following a stimulus

object) is punished, even though training and testing occur in entirely different contexts.

In the first of two conceptually similar studies (Wong, 1971a), rats were initially coerced to make an approach response that produced punishment but not reinforcement. Coercion was accomplished by placing the Ss in a small tubular runway that was slanted down toward the goal section (i.e., Ss could not retrace but were constrained to go only in a forward direction). The Ss that were trained with the coerced approach procedure were more resistant to punishment under noncoercive conditions, relative to unpunished controls. Furthermore, the coerced Ss were more resistant to unpunished extinction of a subsequently food rewarded running response in a straight alley runway than unpunished control Ss. These persistence effects obtained whether the coerced Ss were punished intermittently (Exp. I) or continuously (Exp. II).

In the second study (Wong, 1971b), four groups of rats were given the following treatments in the first phase of a three phase experiment. One group (Group CA) received coerced approach training in the manner described in the previous study. A second group (Group PC) received punishment for competing responses (i.e., stopping, turning or retracing behaviors). A third group (Group FS) received free shock that was noncontingent upon S's responses. The distribution of shocks for Group FS was yoked to the shocks administered to Group PC. Finally, a fourth group received unpunished, continuous reinforcement training. None of the three experimental groups received positive reinforcement training in the initial phase of the experiment. In the second phase, all Ss were given continuous, positive reinforcement training. In the third phase, the food rewarded running response was extinguished (unpunished extinction). It was found that all

Ss experiencing punishment in phase one were more resistant to extinction relative to the unpunished continuously reinforced controls. In addition, the extinction performance of Group PC and Group CA was superior to that of Group FS. These data indicate that the greatest response persistence is observed when Ss are trained to make an approach response in the presence of punishment stimuli, and the procedure used to produce the approach response is not crucial (i.e., the performance of Group PC and Group CA was nondifferential). More importantly, these data indicate that positive reinforcement need not be simultaneously administered with punishment in order to produce punishment persistence effects; rather positive reinforcement may represent merely another procedure for insuring the occurrence of an approach response. This latter finding is of considerable theoretical importance and more will be said about it later in this review.

Noncontingent Punishment Training.--In the studies reviewed thus far, punishment has been presented contingent upon a particular response. When noncontingent punishment is preexposed in the absence of positive reinforcement, subsequent resistance to contingent punishment is often decreased (Kurz & Walters, 1962; Pearls, Walters & Anderson, 1964). This effect has been found when training and testing were separated by one year (Walters & Rogers, 1963) and also when the noncontingent punishment preexposure has been administered employing a spaced trials procedure (Terris & Brown, 1967).

Although the bulk of the operant literature is to be reviewed separately a series of operant studies by Raymond (1969) will be reviewed here, since a noncontingent preexposure period of punishment was used and the punishment was administered in the context of positive reinforcement. The same general procedure was used in all the experiments. Rats were trained to

bar press on a 22-response fixed ratio (FR 22) schedule of reinforcement, and this schedule was in effect throughout the remainder of the experiment. After this initial training, Ss were assigned to an experimental group that received noncontingent punishment or a control group that did not receive punishment. Punishment was administered on the average of every 2 minutes, independent of responding. Following this, all groups received additional training without punishment, allowing Ss to recover from the effects of punishment. Finally, the Ss were tested with a VI 2 minute schedule of punishment (response contingent) superimposed on the FR 22 schedule of reinforcement. The initial experiments indicated that severe noncontingent punishment reduced resistance to subsequent mild contingent punishment whereas mild noncontingent preexposure of punishment increased resistance to subsequent severe contingent punishment. In subsequent experiments, Raymond (1969) found that moderate intensity noncontingent punishment increased persistence to subsequent severe punishment but decreased persistence to subsequent mild punishment. It appears from these data that noncontingent preexposure to punishment will accentuate or attenuate subsequent performance to contingent punishment depending upon the relationship between the preexposed punishment intensity and subsequent punishment intensity. Raymond (1969) argued that a given intensity neither sensitizes nor adapts a S to subsequent exposures to punishment. Rather, the Ss behave in a manner intermediate between that appropriate to the punishment (as determined by control Ss without prior exposure to punishment) and the rate they previously adopted during preexposure. This "inertia" hypothesis suggests that previous attenuation and accentuation effects due to noncontingent preexposure may, in fact be examples of generalization.

Free Operant

The effect of punishment on operant behavior has been described in an earlier review (Azrin & Holz, 1966), consequently the present review will be selective.

Schedules of Punishment.--The schedule of punishment has been shown to affect both the overall rate and the temporal distribution of operant responding (Azrin & Holz, 1966). For example, the overall rate of responding decreases as the proportion of punished responses increases (Azrin, Holz & Hake, 1963). Similarly, fixed interval schedules of punishment produce a temporal pattern of responding which is a mirror image of that observed under fixed interval reinforcement schedules (Skinner, 1938), i.e., negative acceleration of the response results (Azrin, 1956). In addition, variable interval (VI) schedules of punishment produce greater suppression that fixed ratio (FR) schedules under conditions that roughly equate punishment density (Camp, Raymond & Church, 1966).

Schedules of Reinforcement.--The schedule of reinforcement is an important factor in determining the effect of punishment. Time based reinforcement schedules that are accompanied by continuous punishment (FR 1) produce performance that is depressed but uniform (Azrin, 1960a; 1960b; Brethower & Reynolds, 1962; Dinsmoor, 1952; Holz & Azrin, 1961). On the other hand, punishment of response based reinforcement schedules affect both overall rate and length of postreinforcement pause. Continuous punishment (FR 1) superimposed upon FR responding lengthens the post reinforcement pause but the high response rate following the pause (ratio run) is virtually unaffected (Azrin, 1959). In addition to schedule, reinforcement density determines the degree of supression produced by punishment

(Church & Raymond, 1967). The less dense the reinforcement schedule is, the greater are the suppressive effects of punishment.

Locus of Punishment.--There is evidence that the effectiveness of punishment in suppressing behavior is determined by its locus in a response sequence. For example, Holz & Azrin (1962) found that the amount of suppression produced by punishment depended on its temporal location in a fixed interval (FI) schedule. Punishment administered in the first three quarters of the interval suppressed responding; however punishment administered in the final quarter of the interval did not affect response rate (punishment was response produced). Similarly, Dardano and Sauerbrunn (1964) and Appel (1968) employing ratio schedules of reinforcement found that punishment administered following the first response produced much greater disruption of responding than punishment administered later in the ratio. In another study, Dardano (1970) punished FR performance either in the initial, middle, or final third of the ratio. It was found that performance was most resistant to disruption when punishment was administered on the final third of the ratio. Post reinforcement pauses were lengthened by all punishment loci, but to a greater extent when the first third of the ratio was punished. In a recent experiment (Dardano, 1972), an unsuccessful attempt was made to produce within-subject preferences for different loci of punishment in a three-component multiple schedule (i.e., punishment of the first, middle, or final response in an FR 70 schedule). DeArmond (1966) employed a multiple FR schedule of reinforcement and punished single responses in each component, varying the position of punishment in each component. The position of punishment within the ratio requirement determined the change in local rate. Punishment occurring following the initial response increased post reinforcement pausing. Punish-

ment delivered following the middle response disrupted responding during the first half of the ratio. Punishment of the last response in the ratio resulted in a deceleration of response rate as the ratio requirement neared completion. The experiments showing that differential performance may be produced by varying the locus of punishment in a response sequence provide indirect support for the notion that punishment stimuli may have discriminative properties and that punished reactions may be brought under stimulus control.

Discriminative Properties of Punishment.--Azrin and Holz (1966) emphasized the discriminative properties of punishment. In addition to being aversive, punishment may function as a signal (discriminative stimulus) for other events (i.e., subsequent punishment, nonreinforcement, or reinforcement). When punishment predicts subsequent punishment a single punished response may suppress behavior for long period of time (Dinsmoor, 1952). In contrast, when punishment predicts the absence of further punishment, very little suppression following the punished response is observed (Azrin, Holz & Hake, 1963). In a study by Williams and Barry (1969), food and shock punishment were programmed on identical VI 1 min schedules but the temporal relationship between these two schedules was varied. It was found that the effectiveness of punishment in suppressing performance was an inverse function of the temporal relationship between reinforcement and punishment. Presumably when reinforcement and punishment occur temporally close to each other, punishment is more readily established as a discriminative stimulus for reinforcement than when the two stimuli are temporally separated.

A number of studies have found that punished extinction produces a more rapid decrement in performance relative to unpunished extinction (Boe,

1966; Estes, 1944), although when mild punishment stimuli are used suppression may be only temporary (Skinner, 1938). This result is generally attributed to the aversive properties of punishment, but the discriminative properties of punishment may also contribute to this finding. Punishment that is introduced in extinction is, by definition, selectively associated with nonreinforcement. Therefore, to some degree, performance may be suppressed due to the fact that punishment signals nonreinforcement. Support for this notion was first reported by Holz and Arzin (1961). In this classic study, Ss received training periods of VI 2 min reinforcement alternated with periods of extinction (no exteroceptive stimuli were used). For one group of Ss punishment was correlated with reinforcement and for a second group, punishment was correlated with extinction. It was found that the Ss that had experienced punishment in the context of reinforcement actually increased responding when punishment was suddenly introduced in extinction! In contrast, the Ss that had experienced the correlation between punishment and nonreinforcement almost ceased responding entirely when punishment was introduced in extinction. In a similar study with mental hospital patients, Allyon and Azrin (1966) demonstrated that when punishment was selectively associated with reinforcement it served as both a discriminative stimulus and as a conditioned reinforcer.

Conditioned Reinforcing Properties of Punishment Stimuli.--The notion that punishment stimuli can assume the properties of a conditioned reinforcer has been the subject of considerable investigation. For example, Murray and Nevin (1967) trained rats on a two-bar chained schedule such that the first response on the left bar after 30 seconds produced a light stimulus consistently and a shock stimulus 50% of the time (FI 30 sec). A bar press on the right bar produced reinforcement 50% of the time (VR 2).

One group received reinforcement for responding in the presence of light plus shock (positive correlation) but not in the presence of light alone. A second group received reinforcement for responding in the presence of light alone (negative correlation) but not in the presence of light plus shock. A third group received 50% reinforcement for responding in the presence of light plus shock and light only (uncorrelated). The experiment was performed first with .4 mA shock intensity and then with .8 mA intensity. Conditioned reinforcing properties were measured in the first component of the chained schedule (rate of responding on the left bar). The results clearly indicated facilitation for the positively correlated group and suppression for the negative correlation group, relative to the uncorrelated control group. These results were obtained only when .4 mA shock intensity was used; when .8 mA shock was used all groups showed suppression. These data suggest that punishment stimuli may function as conditioned reinforcers when they are positively correlated with reinforcement, and when punishment is not too intense. It should be noted in this regard that Davidson (1970) in a conceptually similar experiment, found that punishment correlated with reinforcement became a conditioned reinforcer when a moderate intensity of shock was used (.3 mA), but not when a high intensity was used (.6 mA). Also, Allyon and Azrin (1966) in their demonstration used what must be considered a mild punishing stimulus (60 cps buzzer at 98 db).

Snow (1971) compared the discriminative and conditioned reinforcing properties of aversive and initially neutral stimuli. Pigeons were trained on a three component, multiple schedule. When the response requirement for each component was met (FR 20 in each case) each of the three components yielded reinforcement on 50% of the trials and punishment on 50% of the

trials. Positive reinforcement followed the last response of a trial (on 50% of the trials) whereas aversive or neutral stimuli were presented after the first response. One group received neutral stimuli (tone) and the other group received aversive stimuli (shock). Neutral or aversive stimuli in the three components of the multiple schedule were programmed so that they predicted reinforcement (positive correlation), nonreinforcement (negative correlation), or both (no correlation). In the component where stimuli were positively correlated with reinforcement performance was facilitated. Conversely, in the component where stimuli were negatively correlated with reinforcement performance was inhibited. These effects were measured relative to the trials in which no stimulus presentations occurred. Interestingly, originally neutral and aversive stimuli yielded identical performance across all three contingencies. Following training, all Ss were extinguished in all three components with the stimulus presentations in effect on each trial. It was found that both aversive and initially neutral stimuli produced component stimulus control during extinction. That is, Ss were more resistant to extinction in the component in which stimuli (both aversive and initially neutral) were positively correlated with reinforcement. Performance was intermediate in the component associated with no correlation and poorest in the component associated with negative correlation between stimuli and reinforcement. These data indicate that aversive and initially neutral stimuli function similarly as conditioned reinforcers in situations where they predict reinforcement. Conversely, both types of stimuli function as punishers when they signal nonreinforcement. In general, the evidence for the notion that punishment stimuli can assume conditioned reinforcing properties is good, providing that the punishing stimulus is not too intense.

Punishment Extinction Effects

With some exceptions, most of the operant literature reviewed thus far has been concerned with the effects of punishment upon steady state performance. There is however, a growing body of operant literature that is concerned with the effects of punishment during punished extinction.

Continuous Reinforcement-Partial Punishment.--The intermittent punishment effect has been found in operant situations (Birch, 1965; Keller & Shoenfeld, 1950). Furthermore, Green (1972) has recently shown that the IPE may be produced not only when food reinforcement is used, but also when electrical brain stimulation is used as the reinforcing event.

Partial Reinforcement-Partial Punishment.--The above mentioned studies demonstrated increased response persistence following punishment training in the presence of continuous reinforcement. However, more dramatic persistence effects are produced when punishment training is administered during partial reinforcement (Akhtar, 1967; 1968a; 1968b; 1970; Akhtar & Bond, 1968). In the first of a series of experiments, Akhtar (1967) punished rats so that punishment predicted either reinforcement or additional punishment for the next response. In addition, Ss that had punishment predicting reinforcement received training on either a VR or FR schedule of punishment. The VR schedule of punishment gradually increased the proportion of punished responses so that on the last day of training 19 out of 20 responses were punished. A nonpunished, continuously reinforced control group was also included. One half of the Ss in each group received limited training (7 days) whereas the other half received extended training (17 days). It was found that extended training increased resistance to punished extinction. Furthermore, prior experience with punishment that signalled reinforcement (FR and VR) resulted in greater persistence

to punished extinction relative to Ss that had punishment signalling the advent of further punishment (reinforcement and punishment density was constant across groups). Both the procedure and results of this study bear a great deal of similarity to the sequential, discrete trials investigations of Campbell, Wroten and Cleveland (in press) and Capaldi and Levy (1972).

Akhtar and Ahsan (1970) subsequently replicated the above experiment with the addition of a VR group that received a constant proportion of punished responses throughout training (constant VR groups). This group differed from the VR group in the first study in that Ss in the first study received a progressively increasing proportion of daily punished responses as training progressed (progressive VR group). The results showed that there were no performance differences in punished extinction between the FR group and the constant VR group, but both were superior to the progressive VR group. The persistence to punished extinction in both this and the preceding study was phenomenal (Ss in the FR and VR groups continued to respond after 50 days!); although some of this behavior was shown to be due to immediate post-session feeding (Akhtar & Bond, 1968). Performance declined when the Ss were detained for one half hour before post-session feeding.

Persistence in discrete trials experiments has been shown to increase with greater magnitudes of reinforcement following punishment (Capaldi & Levy, 1972; Exp II). In a comparable experiment in an operant setting the quality of reinforcement was varied (Akhtar, 1970). It was found that Ss receiving "better tasting" food pellets during partial punishment training were more resistant during punished extinction than Ss receiving "poorer tasting" pellets. The food pellets differed only in taste (the multi-

dimensional cues were identical). Although different groups received qualitatively different reinforcement during training, no distinction was made between differential quality of reinforcement on trials preceding or following punishment. It is interesting to speculate whether the locus of the punishment persistence effect would be in the quality of the reinforcement following punishment as is the case with magnitude of reward.

Punishment of Multi-Response Dimensions

In the studies reviewed thus far, investigators have chosen one response dimension such as rate or speed and have largely ignored other dimensions. However, Filion, Fowler and Notterman (1969) have reported a unique study in which two different response dimensions (force and rate of bar pressing) were simultaneously exposed to reinforcement and punishment contingencies. Two groups of rats were given identical force-proportional positive reinforcement schedules but different schedules of simultaneous force-proportional punishment. By force-proportional it is meant that the probability of receiving reinforcement is positively correlated with the force of a given bar pressing response. The effect of this procedure on acquisition performance was to decrease the force of the responses in the group receiving the lower force criterion relative to the group receiving the higher force criterion. Interestingly, rate of bar pressing was unaffected by the differential force contingencies. In unpunished extinction the reverse was true. Force of responding between groups was nondifferential, however the Ss trained with the low criterion shock schedules bar pressed at a higher rate relative to Ss trained with the high criterion shock level. The paradoxical extinction data is probably a result of the two groups receiving differential frequencies of reinforcement during training (i.e., the Ss under the low shock criterion responded with less

force and therefore were less likely to receive reinforcement). This preliminary effort to study two responses dimensions simultaneously indicates: (a) that force and rate dimensions may be differentially sensitive to punishment, and (b) there exists a tendency for compensatory interaction between the two response dimensions (there was a trend for rate to increase when force decreased).

Selective Learning

A number of studies have investigated the effects of punishment during discrimination training on performance during subsequent reversal shifts. These studies indicate that punishment impairs subsequent reversal performance (Karsh, 1970; 1971; Kleban, 1968; Koski & Ross, 1965; Yaremko, Johnson, Maddox & Leckart, 1971). Earlier studies indicated that punishment produces fixation in selective learning, but most of this work (e.g., Farber, 1948) involved escape and avoidance learning in addition to punishment (cf. Church, 1963).

Karsh (1970; 1971) reports that fixation (resistance to reversal) is found only when a conflict procedure is employed. That is, when reward and punishment are simultaneously administered for the incorrect response during training. When training consists of punishment plus nonreinforcement for the incorrect response, reversal learning is facilitated relative to unpunished controls. Koski and Ross (1965) found that the effectiveness of punishment in retarding reversal performance depended on when punishment was introduced in training. The Ss were punished while lapping water during acquisition and during four reversals of a spatial problem. Control Ss were given discrimination training without punishment. Punishment was introduced early in training for one group and late in training for a second group (after 10 successive correct choices). The results indicated

that the group punished early in training fixated during reversal whereas the group punished after reaching criterion did not fixate. Thus it appears that punishment will retard reversal learning only if it is administered when Ss are in the process of learning the original problem. In general, punishment administered in the context of reinforcement produces response persistence in choice situations in much the same way as in instrumental and operant settings. Moreover, in the choice situation the effect of punishment is to retard later reversal learning. Clearly more research is needed in this area since so much of the work has confounded the punishment of appetitively based behavior with aversive contingencies operative in the same situation.

Some Theoretical Positions

The finding that punishment administered in appropriate contexts produces increased response persistence has been interpreted via theoretical mechanisms similar to those proposed to account for the partial reinforcement effect. In this review two nonsequential theories (Amsel, 1962; 1967; in press; Lawrence & Festinger, 1962) and one sequential theory (Capaldi, 1966; 1967; 1970) will be evaluated with regard to existing data.

Frustration Theory

Amsel's (1962; 1967) frustration account of the partial reinforcement effect posits that nonreinforcement to an organism anticipating reinforcement (r_R), generates primary frustration (R_F) which is eventually anticipated (r_F). When reinforcement occurs in the presence of anticipatory frustration (r_F), the stimulus properties of r_F, s_F, are counterconditioned to approach behaviors. Thus the counterconditioning of cues associated with anticipatory frustration provides the mechanism of the partial reinforcement effect. Ths same sort of analysis has been applied to account for the IPE

(Brown & Wagner, 1964; D'Amato, 1969; Wagner, 1966; 1969) by merely substituting anticipatory pain (r_p) for r_F. Recently, Amsel (in press) has proposed a more general theory of persistence in which r_p and r_F are viewed as subsets of a more inclusive class of aversive events. According to this modified analysis, the stimulus properties of a wide variety of aversive events may be connected to approach behaviors thereby providing the mechanism for the development of generalized persistence. The association of the stimulus properties of aversive events to approach behaviors is accomplished by contiguity. Reinforcement is important only in that it insures the occurrence of approach behavior; however it is not unique since other procedures that accomplish this are equally effective (i.e., coercion, punishment of responses that are incompatible with approach).

The most convincing support for Amsel's modified analysis comes from a series of experiments in which transituational response persistence is demonstrated despite the explicit omission of reinforcement during punishment training (Amsel, Wong & Scull, 1971; Wong, 1971a; 1971b). These data provide support for the notion that any procedure which insures the occurrence of approach behavior in the context of aversive stimuli will increase response persistence. Furthermore, these data are damaging to any theory that holds to a hard principle of reinforcement (Capaldi, 1967).

Although Amsel's (in press) modified frustration theory predicts well in situations where punishment training occurs in the absence of positive reinforcement, the theory lacks precision when it attempts to make predictions in situations where punishment training is accompanied by positive reinforcement. For example, the modified frustration theory cannot account for the effects of sequential manipulations demonstrated by Campbell et. al. (in press) and Capaldi and Levy (1972). In these studies

it was shown that the sequence of reinforcement and punishment events was a critical determinant of response persistence. In addition, the evidence from a large body of operant research demonstrating differential effects of punishment due to "position effects" (sequence) does not fit well with a theory that does not provide for sequential effects. In particular, experiments by Akhtar (1967), Dardano (1970), DeArmond (1966) and Holz and Azrin (1961; 1962) indicate the importance of the locus of punishment in determining performance rather than the number of reinforcement and punishment events per se. Thus, the modified frustration theory advanced by Amsel (in press) is viable in situations in which punishment training occurs in the absence of positive reinforcement, but lacks precision in predicting behavior in situations where punishment is accompanied by positive reinforcement.

Cognitive Dissonance Theory

Lawrence and Festinger (1962) have advanced a theoretical interpretation of behavioral persistence through an application of cognitive dissonance theory. In a partial reinforcement situation, nonreinforcement occasions dissonance due to the fact that the S expects reinforcement and expends effort to reach the goal. In an attempt to reduce the dissonance occasioned by nonreinforcement, the S develops an extra preference for the goal box and the activity itself. The partial reinforcement extinction effect is observed due to the fact that partial reinforcement Ss have developed this extra preference for the "pretty goal box" whereas continuously reinforced Ss have not. Assuming that punishment, like nonreinforcement, is dissonance producing, the theory would predict punishment persistence effects. Cognitive dissonance theory like frustration theory is nonsequential, therefore it cannot handle the results obtained with

sequential manipulations. Furthermore, the evidence demonstrating transituational persistence following training with punishment in the absence of reinforcement is particularly damaging to dissonance theory. In fact, the experiments in which Ss were coerced to approach the goal (Wong, 1971a; 1971b) are analogous to forced compliance situations which are not conducive to the development of dissonance. The inability of dissonance theory to handle existing data makes it less than viable.

Sequential Theory

Sequential theory assumes that different goal box events occasion distinctive memory stimuli that may be modified by succeeding trials or conditioned to instrumental behaviors. In a partial reinforcement situation, the capacity of nonreinforcement related stimuli to control instrumental performance depends upon the sequence of nonreinforcement-reinforcement events experienced during training. According to a sequential analysis, the mechanism of increased resistance to extinction in a partial reinforcement situation depends upon the strength with which nonreinforcement aftereffects (S^N) have been conditioned to instrumental approach behavior (R_I), or in Capaldi's terms, the strength of the S^N-R_I association. Sequence is crucial due to the fact that S^N is conditioned to R_I on reinforced trials that follow nonreinforced trials (N-R transitions). However, no conditioning of S^N to R_I occurs when reinforced trials precede, but do not follow nonreinforced trials (R-N transitions). There is ample evidence to support this analysis (cf. Capaldi, 1967). Extending sequential theory to include the effects of punishment is relatively straightforward since evidence from several pattern discrimination studies (Campbell, Crumbaugh, Marshall & Sparling, 1972; Campbell, Crumbaugh, Massey & Reed, 1972) indicate that punishment, like nonreinforcement, produces patterning when pre-

sented on a single alternation schedule. These experiments indicate that punishment produces a unique stimulus aftereffect and suggest that punishment may be profitably considered from a sequential viewpoint. Sequential theory assumes that the aftereffects of punishment (S^P), like S^N, are conditioned to approach behaviors (R_I) on reinforced trials following punished trials (P-R transitions) but not on reinforced trials that precede but do not follow punished trials (R-P transitions). Strong support for this analysis was found in two separate investigations (Campbell, et.al., in press; Capaldi & Levy, 1972). That is, P-R transitions were found to increase response persistence relative to R-P transitions, despite the fact that the number of reinforced and punished trials were held constant. In addition, similar results have often been obtained in operant investigations (i.e., Akhtar, 1967; Azrin & Holz, 1966; Church, 1969). In fact, Church (1969) reports that the suppressive effects of punishment largely depend upon which response in a response sequence is punished. Although in many of the operant studies a sequential interpretation of the data is confounded by the ordinal position of punishment, Capaldi and Levy, Exp. II (1972) unconfounded these variables and found clear support for a sequential analysis. It was found that the magnitude of reinforcement on P-R transitions was positively related to performance, whereas the magnitude of reinforcement on R-P transitions was negatively related to performance.

Although preliminary investigations have generally supported sequential theory a number of sequential effects have yet to be demonstrated. For example, there has not been any attempt to demonstrate with punishment, effects corresponding to N-length (i.e., number of successive punishment trials preceding reinforcement). Furthermore, studies investigating the effect of placement procedures have not been reported. Kinler and Banks

(1969) did not find increased response persistence as a function of inter-trial punishment placements; however this failure may be a function of the large number of placements that were employed. It has been previously argued that placements lose their effectiveness if a large number is given, due to the fact that Ss come to discriminate placement events from running trials (Capaldi, 1967).

The studies demonstrating transituational persistence when punishment training occurs in the absence of positive reinforcement (Amsel, Wong & Scull, 1971; Wong, 1971a; 1971b) are difficult to interpret from a viewpoint that assumes a hard principle of reinforcement. One is hard put, to find reinforcement during the punishment phase of these experiments. Thus, S^P should not be conditioned to R_I and increased response persistence relative to unpunished controls should not be observed. Obviously, some modification of sequential theory is required to account for persistence effects obtained in the absence of positive reinforcement. Of course, if it is assumed that stimulus aftereffects may become conditioned to instrumental behaviors by contiguity rather than reinforcement, sequential theory is able to handle the existing data. Such contiguity explanations have recently been revived (e.g., Bolles, 1972; Rescorla & Solomon, 1967) and if they were to be incorporated within the framework of Capaldi's sequential theory it would be consistent with most of the data reviewed in this paper.

Summary

In this review, we have focused on the effects of punishment on appetitively based behavior. Generally, it is found that punishment administered in the context of positive reinforcement produces increased response per-

sistence. This increased persistence has been shown to generalize to novel testing situations; however there is only weak support for generalization of persistence when novel testing stimuli are employed (i.e., Terris & German, 1969). An evaluation of the major theories of response persistence with regard to existing data indicates that when punishment training is accompanied by positive reinforcement, sequential theory appears to provide the most precise account of the data. However, it has been noted that a large number of sequential effects demonstrated with nonreinforcement have as yet not been demonstrated with punishment. In particular, studies investigating P-length effects (analogous to N-length) and placement manipulations are badly needed. In addition, more research that focuses on the interaction between acquisition sequences and kind of response decrement stimuli employed in testing would provide a fairly direct test between Amsel's modified frustration theory and Capaldi's sequential theory.

Although sequential theory handles the data quite well in situations where punishment and reinforcement are administered in the same phase; Amsel's theory better accounts for persistence effects produced by situations in which punishment is administered in the absence of reinforcement. However, it was noted that Capaldi's sequential theory would be able to handle the data from experiments in which positive reinforcement was not given if assumptions regarding contiguity were made. In general, the punishment of appetitively based behavior affects behavioral persistence in much the same manner as nonreinforcement and delayed reinforcement. The primary effect of punishment like that of nonreinforcement or delay is to suppress behavior but through learning these stimuli may occasion various systematic behavioral changes.

Proposal

In a recent review of the partial reinforcement literature (Robbins, 1971) the conclusion is reached that sequential theory represents the most satisfactory account of partial reinforcement phenomenon to date. The research to be proposed represents an attempt to extend sequential theory to deal with punishment effects. To date there has been little research investigating sequential variables in partial punishment investigations (Campbell, Wroten & Cleveland, 1972; Capaldi & Levy, 1972), and in view of the encouraging results of these preliminary attempts further efforts seem to be warranted.

In the first of two experiments, two groups of Ss will be given partial punishment and partial reinforcement so that one group (Group PR) will receive transitions from punishment to reinforcement (P-R transitions) and a second group (Group NR) will receive transitions from nonreinforcement (N-R transitions). Both groups will receive the same "number" of *nonreinforcement-reinforcement-punishment* events; only the "sequence" will be varied. An additional group (Group RR) will receive continuous reinforcement. Following training, the three groups will be split in testing so that one half of the Ss in each group will receive punished extinction whereas the other half will receive unpunished extinction. If it is assumed that stimuli occasioned in unpunished extinction (S^N) differ from those in punished extinction (S^P), it might be expected that differential group performance will be related to the kind of response decrement procedure used (i.e., punished versus unpunished extinction). More specifically, it is hypothesized that Group PR will be superior to Group NR in punished extinction since Group PR will be trained with theoretical S^P-R_I

associations. Thus S^P should occasion R_I in punished extinction more readily for Group PR than Group NR (i.e., the latter group will have theoretical S^N-R_I associations established during training). Following this line of reasoning leads to the opposite prediction for performance in unpunished extinction (Group NR should be superior to Group PR). Thus differential group performance as a function of type of response decrement procedure is predicted despite the fact that both groups will receive the same number of nonreinforcement-reinforcement-punishment events. Of course Group RR is expected to show the poorest performance regardless of the decrement procedure employed due to the fact that nonreinforcement and punishment produce stimuli that are more similar to each other than to reinforcement stimuli.

In the second experiment, two groups of Ss will receive acquisition training identical to Group NR and Group PR in the first experiment. However, each group will receive both response decrement procedures in succession (unpunished, punished and unpunished extinction respectively). In effect, this experiment is designed to replicate the findings of the first experiment using a within-subject response decrement procedure. In addition, it will be interesting to see whether the prior extinction of behavior to nonreinforcement related stimuli will affect the subsequent extinction of behavior to punishment related stimuli.

These experiments are designed to determine the extent to which sequential manipulations involving nonreinforcement-reinforcement-punishment events can gain discriminative stimulus control of instrumental behavior. More generally, the proposed research represents an attempt to study sequential variables as they relate to punishment persistence effects, and

to compare the findings obtained with similar manipulations involving partial reinforcement.

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APPENDIX B

ANOVAS

Table 1

Analyses of Variance on the Last Five Days of Acquisition

for the Four Speed Measures:

Experiment I

Start

Source	df	MS	F
Between	59	35.30	
A (Groups)	2	59.18	1.76
B (Response Decrement)	1	19.90	.59
AB	2	66.92	1.99
Error	54	33.53	
Within	240	4.26	
C (Days)	4	24.24	6.10**
AC	8	6.87	1.73
BC	4	1.29	.32
ABC	8	1.13	.28
Error	216	3.97	

Run

Source	df	MS	F
Between	59	.19	
A (Groups)	2	.07	.36
B (Response Decrement)	1	.04	.18
AB	2	.37	1.94
Error	54	.19	
Within	240	.02	
C (Days)	4	.05	2.16
AC	8	.03	1.20
BC	4	.01	.03
ABC	8	.03	1.36
Error	216	.02	

Goal

Source	df	MS	F
Between	59	1.23	
A (Groups)	2	9.40	9.64**
B (Response Decrement)	1	.02	.02
AB	2	.73	.75
Error	54	.97	
Within	240	.26	
C (Days)	4	4.90	26.02**
AC	8	.36	1.90
BC	4	.42	2.23
ABC	8	.15	.83
Error	216	.18	

Total

Source	df	MS	F
Between	59	.09	
A (Groups)	2	.22	2.54
B (Response Decrement)	1	.02	.27
AB	2	.12	1.45
Error	54	.08	
Within	240	.01	
C (Days)	4	.06	8.68**
AC	8	.01	1.82
BC	4	.01	.79
ABC	8	.01	.67
Error	216	.01	

*p <.05

**p <.01

Table 2

Analyses of Variance on the Five Days of Response Decrement Testing (Punished vs Unpunished Extinction) for the Four Speed Measures: Experiment I

Start

Source	df	MS	F
Between	59	33.52	
A (Groups)	2	292.90	19.47**
B (Response Decrement)	1	333.15	22.15**
AB	2	123.44	8.20**
Error	54	15.03	
Within	240	10.86	
C (Days)	4	325.58	55.16**
AC	8	27.27	4.62**
BC	4	1.23	.21
ABC	8	6.25	1.05
Error	216	5.90	

Run

Source	df	MS	F
Between	59	1.27	
A (Groups)	2	13.92	46.21**
B (Response Decrement)	1	24.28	80.58**
AB	2	3.35	11.13**
Error	54	.30	
Within	240	.30	
C (Days)	4	10.30	82.50**
AC	8	.41	3.34**
BC	4	.23	1.86
ABC	8	.19	1.55
Error	216	.12	

Goal

Source	df	MS	F
Between	59	5.29	
A (Groups)	2	50.29	31.87**
B (Response Decrement)	1	93.50	59.26**
AB	2	16.39	10.39**
Error	54	1.57	
Within	240	1.50	
C (Days)	4	53.87	91.29**
AC	8	2.78	4.70**
BC	4	.45	.77
ABC	8	2.15	3.65**
Error	216	.59	

Total

Source	df	MS	F
Between	59	.40	
A (Groups)	2	4.97	50.59**
B (Response Decrement)	1	5.58	56.85**
AB	2	1.42	14.40**
Error	54	.09	
Within	240	.12	
C (Days)	4	4.90	124.34**
AC	8	.35	8.81**
BC	4	.04	1.25
ABC	8	.13	3.17**
Error	216	.03	

*p <.05

**p <.01

Table 3

Analyses of Variance on the Last Five Days of Acquisition for the Four Speed Measures: Experiment II

Start

Source	df	MS	F
Between	19	34.53	
A (Groups)	1	5.48	.15
Error	18	36.14	
Within	80	5.58	
B (Days)	4	9.87	1.89
AB	4	7.65	1.46
Error	72	5.23	

Run

Source	df	MS	F
Between	19	.11	
A (Groups)	1	.35	3.58
Error	18	.09	
Within	80	.04	
B (Days)	4	.20	5.09**
AB	4	.02	.60
Error	72	.03	

Goal

Source	df	MS	F
Between	19	1.00	
A (Groups)	1	.28	.27
Error	18	1.04	
Within	80	.35	
B (Days)	4	2.50	10.19**
AB	4	.14	.56
Error	72	.24	

Total

Source	df	MS	F
Between	19	.06	
A (Groups)	1	.04	.60
Error	18	.06	
Within	80	.01	
B (Days)	4	.03	4.83**
AB	4	.01	1.69
Error	72	.01	

*$p < .05$

**$p < .01$

Table 4

Analyses of Variance on Phase I of Response Decrement Testing (Unpunished Extinction) for the Four Speed Measures: Experiment II

Start

Source	df	MS	F
Between	19	21.37	
A (Groups)	1	.03	.01
Error	18	22.55	
Within	20	11.25	
B (Days)	1	74.83	9.23**
AB	1	4.26	.53
Error	18	8.10	

Run

Source	df	MS	F
Between	19	.12	
A (Groups)	1	.08	.70
Error	18	.11	
Within	20	.07	
B (Days)	1	.99	43.81**
AB	1	.01	.38
Error	18	.02	

Goal

Source	df	MS	F
Between	19	.78	
A (Groups)	1	.83	1.06
Error	18	.78	
Within	20	.18	
B (Days)	1	2.30	35.78**
AB	1	.07	1.16
Error	18	.06	

Total

Source	df	MS	F
Between	19	.08	
A (Groups)	1	.04	.55
Error	18	.07	
Within	20	.01	
B (Days)	1	.13	22.65**
AB	1	.01	.16
Error	18	.01	

*$p < .05$

**$p < .01$

Table 5

Analyses of Variance on Phase II of Response Decrement Testing (Punished Extinction) for the Four Speed Measures: Experiment II

Start

Source	df	MS	F
Between	19	18.65	
A (Groups)	1	32.39	5.45*
Error	18	15.10	
Within	20	2.83	
B (Days)	1	37.82	39.02**
AB	1	1.41	1.45
Error	18	.97	

Run

Source	df	MS	F
Between	19	.36	
A (Groups)	1	2.63	11.02**
Error	18	.24	
Within	20	.16	
B (Days)	1	2.36	46.13**
AB	1	.01	.01
Error	18	.05	

Goal

Source	df	MS	F
Between	19	1.30	
A (Groups)	1	6.10	5.93*
Error	18	1.03	
Within	20	.98	
B (Days)	1	15.35	74.60**
AB	1	.58	2.80
Error	18	.21	

Total

Source	df	MS	F
Between	19	.14	
A (Groups)	1	.81	8.06*
Error	18	.10	
Within	20	.07	
B (Days)	1	1.15	74.33**
AB	1	.05	3.40
Error	18	.02	

*$p < .05$

**$p < .01$

Table 6

Analyses of Variance on Phase III of Response Decrement Testing (Unpunished Extinction) for the Four Speed Measures: Experiment II

Start

Source	df	MS	F
Between	19	6.91	
A (Groups)	1	20.43	3.31
Error	18	6.16	
Within	20	1.90	
B (Days)	1	15.21	12.15**
AB	1	.17	.13
Error	18	1.25	

Run

Source	df	MS	F
Between	19	.33	
A (Groups)	1	1.32	4.72*
Error	18	.28	
Within	20	.13	
B (Days)	1	.31	2.88
AB	1	.35	3.17
Error	18	.11	

Goal

Source	df	MS	F
Between	19	.80	
A (Groups)	1	4.33	7.19*
Error	18	.60	
Within	20	.26	
B (Days)	1	.25	.90
AB	1	.08	.29
Error	18	.27	

Total

Source	df	MS	F
Between	19	.07	
A (Groups)	1	.29	4.89*
Error	18	.06	
Within	20	.02	
B (Days)	1	.03	1.30
AB	1	.01	.16
Error	18	.02	

*$p < .05$

**$p < .01$

Table 7

Analyses of Variance on the First Day of Phase II Response Decrement Testing (Punished Extinction) for the Four Speed Measures: Experiment II

Start

Source	df	MS	F
Between	19	45.10	
A (Groups)	1	205.14	5.67*
Error	18	36.21	
Within	60	12.81	
B (Trials)	3	106.30	14.83**
AB	3	20.90	2.92*
Error	54	7.17	

Run

Source	df	MS	F
Between	19	.71	
A (Groups)	1	5.75	13.35**
Error	18	.43	
Within	60	.30	
B (Trials)	3	2.67	17.16**
AB	3	.49	3.13*
Error	54	.16	

Goal

Source	df	MS	F
Between	19	4.15	
A (Groups)	1	24.98	8.36**
Error	18	2.99	
Within	60	.89	
B (Trials)	3	5.73	9.22**
AB	3	.80	1.29
Error	54	.62	

Total

Source	df	MS	F
Between	19	.37	
A (Groups)	1	2.54	10.19**
Error	18	.25	
Within	60	.10	
B (Trials)	3	1.02	24.77**
AB	3	.24	5.86**
Error	54	.04	

*$p < .05$

**$p < .01$

Table 8

Analyses of Variance on the Second Day of Phase II Response Decrement Testing (Punished Extinction) for the Four Speed Measures: Experiment II

Start

Source	df	MS	F
Between	19	19.27	
A (Groups)	1	74.02	4.56*
Error	18	16.23	
Within	60	9.39	
B (Trials)	3	29.99	4.18**
AB	3	28.95	4.04*
Error	54	7.16	

Run

Source	df	MS	F
Between	19	.92	
A (Groups)	1	5.30	7.80*
Error	18	.68	
Within	60	.27	
B (Trials)	3	1.23	7.25**
AB	3	1.21	7.14**
Error	54	.17	

Goal

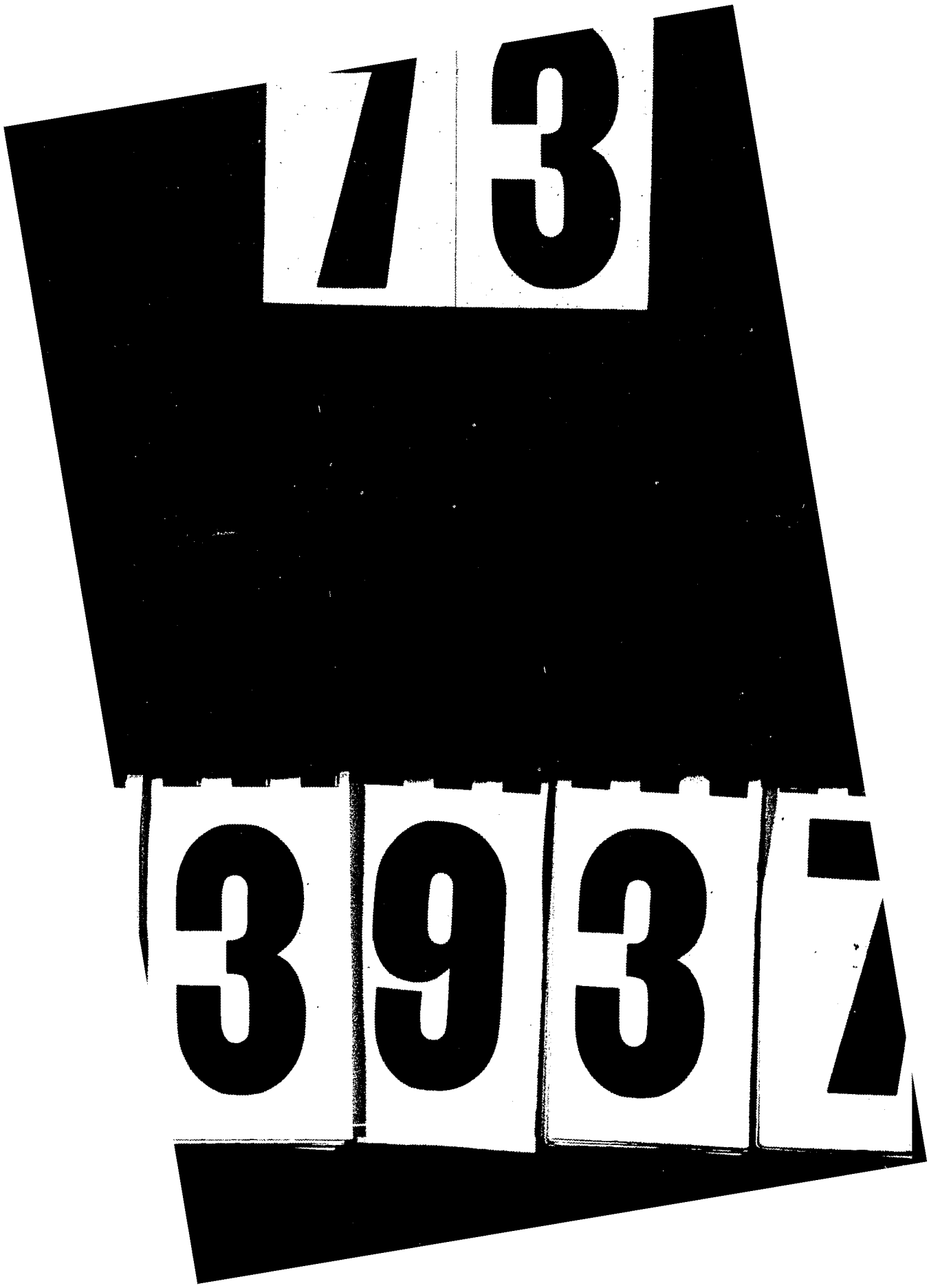
Source	df	MS	F
Between	19	1.90	
A (Groups)	1	5.87	3.48
Error	18	1.68	
Within	60	.59	
B (Trials)	3	2.62	5.89**
AB	3	1.14	2.56
Error	54	.44	

Total

Source	df	MS	F
Between	19	.25	
A (Groups)	1	.89	4.19
Error	18	.21	
Within	60	.06	
B (Trials)	3	.27	5.91**
AB	3	.13	2.91*
Error	54	.04	

*$p < .05$

**$p < .01$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